Notice of Allowability	Application No.	Applicant(s)
	09/976,582	DAFT ET AL.
	Examiner	Art Unit
	Kandasamy Thangavelu	2123

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *31 May 2005*.

2. ☒ The allowed claim(s) is/are *1-37*.

3. ☒ The drawings filed on *31 May 2005* are accepted by the Examiner.

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. ______ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: ______.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

6. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
   1) ☐ hereto or 2) ☐ to Paper No./Mail Date ______.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date ______.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

7. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☒ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO-1449 or PTO/SB/08), Paper No./Mail Date 10/15/2001
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application (PTO-152)
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date ______ .
7. ☒ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☒ Other *Clean copy of allowed claims*.

DETAILED ACTION

Introduction

1. This communication is in response to the Applicant's communication dated May 31, 2005. Claims 1-39 of the application are pending.

Drawings

2. The drawings submitted on October 15, 2001 are accepted.

Examiner's Amendment

3. Authorization for this examiner's amendment was given in a telephone conversation by Mr. Patrick Yoder on August 16, 2005.

An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to the applicants, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

4. In Claim 1:

Replace claim 1 with:

1. A method of jointly optimizing a performance of a probe and imager combination in an ultrasound imaging system, comprising the steps of:

simulating images of a phantom which would be produced by said probe and imager combination in accordance with a statistical design of experiment, a probe geometry specification, and a set of imager parameters, said statistical design of experiment allowing a subset of said imager parameters to vary; and`

quantifying a diagnostic value of each image simulated based at least in part on an image quality specification to produce simulation-based image quality data.

In Claim 6:

Replace claim 6 with:

6. The method as recited in claim 2, further comprising the step of generating transfer functions based at least in part on said simulation-based image quality data.

In Claim 14:

Replace claim 14 with:

14. A computer system comprising a processor, a display monitor, an operator interface, and programming for jointly optimizing a performance of a probe and imager combination in an ultrasound imaging system, comprising:

simulating images of a phantom which would be produced by said probe and imager combination in accordance with a statistical design of experiment selected via said operator interface, a probe geometry specification comprising at least a portion specified via said operator

interface, and a set of imager parameters comprising at least one imager parameter set via said operator interface, said statistical design of experiment allowing a subset of said imager parameters to vary;

controlling said display monitor to display said simulated images; and

quantifying a diagnostic value of each image simulated based at least in part on an image quality specification to produce simulation-based image quality data.

In Claim 23:

Replace claim 23 with:

23. The computer system as recited in claim 19, further comprising programming for generating transfer functions based at least in part on said simulation-based image quality data.

In Claim 31:

Replace claim 31 with:

31. A computer system for jointly optimizing a performance of a probe and imager combination in an ultrasound imaging system, comprising:

a processor;

a display monitor;

an operator interface;

means for simulating images of a phantom which would be produced by said probe and imager combination in accordance with a statistical design of experiment selected via said operator interface, a probe geometry specification comprising at least a portion specified via said

operator interface, and a set of imager parameters comprising at least one imager parameter set via said operator interface, said statistical design of experiment allowing a subset of said imager parameters to vary;

means for controlling said display monitor to display said simulated images; and

means for quantifying a diagnostic value of each image simulated based at least in part on an image quality specification to produce simulation-based image quality data.

In claims 38 and 39:

Delete claims 38 and 39.

A clean copy of the amended claims is attached.

Reasons for Allowance

5. Claims 1-37 of the application are allowed over prior art of record.

6. The following is an Examiner's statement of reasons for the indication of allowable subject matter:

The closest prior art of record shows:

(1) application of statistical design of experiments (SDOE) to efficiently find the optimum operating points in the design of a transducer involving a first and a second matching layers; the bandwidth and impulse response are optimized by properly selecting four interactive

parameters, the acoustic impedance the first and second matching layers and the thickness of the first and second matching layers; statistical design of experiments looks inside the process and understands how to predict the outcome; a list of many influencing factors is made and the list reduced by running a screening experiment to find the main factors which have greatest influence on the outcome; SDOE is efficient because data have to be collected only on response of the system when the parameters are set at their extreme points; prediction equation of the state is derived and all possible results in the variable space searched; the figure of merit for the problem is established as a combination of several responses and plotted on a response surface to find the optimal operating points; it sets the various parameters for maximum performance; computer simulations are used to generate the trials (**McKeighen,** "optimization of broadband transducer designs by use of statistical design of experiments", IEEE 1995);

(2) a medical ultrasound imaging system that automatically adjusts its imaging parameters using an optical correlator to provide improved image quality in real time; the optical correlator is a device that combines the optical and electronic technologies to provide nearly instantaneous pattern matching; the optical correlator rapidly computes a complex optimization metric based on speckle size and uses it to compare images generated using different values of several parameters including receive delays, transmit delays, filter settings, and transmit waveforms; it automatically selects the settings for these parameters to produce images having a high occurrence of small, well defined speckle; the system sequences through a plurality of permutations of the imaging parameters, keeping those which improve the image, until a set of imaging parameters that produces an optimal image is found (**Burke,** U.S. Patent 6,200,267);

(3) an ultrasound imaging system user interface comprising an imaging parameter selection domain that allows a user to easily control imaging parameters to optimize the resolution without the knowledge of many system specific features; the selection domain includes a plurality of domain locations; the domain locations correspond to a plurality of imaging parameter configurations that affect the spatial resolution, temporal resolution and sensitivity; the user interface is designed to configure a subset of the following parameters: operating frequency, operating bandwidth, transmit aperture size, receive aperture size, spatial filters, temporal filters, number of beams acquired in parallel, flow sample count, pulse repetition frequency, velocity scale, dynamic range, ultrasound line density, number of transmit foci and transmit focus length (**Ustuner,** U.S. Patent 5,919,138); and

(4) proper use of optimal design of experiments in order to qualify new improvements to a process through reduction of variability and increased productivity and reliability; statistical methods may be used to generate and analyze data; active data collection systems lead into statistical design of experiments for improvements in the output variables; the designs allow to efficiently study multivariate complex systems; they increase the effort of experimental work; the experiments are run sequentially so that information gained in the earlier stages influences the choices of experimental conditions in the later stages; these designs allow through empirical model building to define relationships between input and output variables; the models allow to optimize the responses by use of steepest ascent technique and to characterize the operational region through response surface methods (**Sredni,** "Design of experiments: A tool for continuous process improvement", IEEE 1992).

Additional state of the art reviewed and considered by the Examiner is found in U.S. Patent Application 2002/0135273; U.S. Patent Application 2002/0042577; U.S. Patent Application 2002/0012289; U.S. Patent 6,751,490; U.S. Patent Application 2002/0050169; U.S. Patent Application 2002/0012999; U.S. Patent 6,623,430; U.S. Patent 6,626,831; U.S. Patent 6,159,150; U.S. Patent 6,370,480; U.S. Patent 6,689,055; U.S. Patent Application 2002/0138007; U.S. Patent 6,400,841; Frank, "The use of experimental design techniques in simulation", ACM 1968.

None of these references taken either alone or in combination with the prior art of record discloses a method and a computer system for jointly optimizing a performance of a probe and imager combination in an ultrasound imaging system, specifically including:

"simulating images of a phantom which would be produced by said probe and imager combination in accordance with a statistical design of experiment, a probe geometry specification, and a set of imager parameters, said statistical design of experiment allowing a subset of said imager parameters to vary".

7. Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

8. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Dr. Kandasamy Thangavelu whose telephone number is 571-272-3717. The examiner can normally be reached on Monday through Friday from 8:00 AM to 5:30 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Leo Picard, can be reached on 571-272-3749. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to TC 2100 Group receptionist: 571-272-2100.

K. Thangavelu
Art Unit 2123
August 16, 2005

Paul L. Rodriguez 8/19/05
Primary Examiner
Art Unit 2125

Clean copy of the allowed claims

1. A method of jointly optimizing a performance of a probe and imager combination in an ultrasound imaging system, comprising the steps of:

simulating images of a phantom which would be produced by said probe and imager combination in accordance with a statistical design of experiment, a probe geometry specification, and a set of imager parameters, said statistical design of experiment allowing a subset of said imager parameters to vary; and

quantifying a diagnostic value of each image simulated based at least in part on an image quality specification to produce simulation-based image quality data.

2. The method as recited in claim 1, wherein said probe geometry specification comprises a specification of layers in said probe, and said simulating step comprises the step of computing an impulse response based at least in part on said specification of layers in said probe.

3. The method as recited in claim 2, wherein said set of imager parameters comprises a definition of aperture geometry, and said simulating step further comprises computing acoustic diffraction based at least in part on said impulse response, said definition of aperture geometry and said phantom.

4. The method as recited in claim 1, wherein at least some of said imager parameters are retrieved from a database containing respective sets of imager parameters for pre-existing probes.

5. The method as recited in claim 2, wherein said step of computing an impulse response employs a one-dimensional acoustic stack design.

6. The method as recited in claim 2, further comprising the step of generating transfer functions based at least in part on said simulation-based image quality data.

7. The method as recited in claim 6, wherein said image quality specification is a function of at least one image quality parameter, and at least one of said transfer functions relates said image quality parameter to said subset of imager parameters.

8. The method as recited in claim 7, further comprising the step of deriving a statistical distribution of said image quality parameter as a function of at least one imager parameter of said subset using at least one of said transfer functions.

9. The method as recited in claim 6, wherein said image quality specification specifies a value representing an overall image quality, and at least one of said transfer functions relates said overall image quality value to said subset of imager parameters.

10. The method as recited in claim 1, wherein said image quality specification is a function of at least the following: an image quality parameter and a range-dependent weighting coefficient corresponding to said image quality parameter.

11. The method as recited in claim 6, further comprising the step of optimizing imager parameters of said probe and imager combination based at least in part on said transfer functions.

12. The method as recited in claim 6, further comprising the step of optimizing said specification of layers in said probe based at least in part on said transfer functions.

13. The method as recited in claim 6, further comprising the step of generating a graph representing image quality as a function of cost based at least in part on said transfer functions.

14. A computer system comprising a processor, a display monitor, an operator interface, and programming for jointly optimizing a performance of a probe and imager combination in an ultrasound imaging system, comprising:

simulating images of a phantom which would be produced by said probe and imager combination in accordance with a statistical design of experiment selected via said operator interface, a probe geometry specification comprising at least a portion specified via said operator interface, and a set of imager parameters comprising at least one imager parameter

set via said operator interface, said statistical design of experiment allowing a subset of said imager parameters to vary;

controlling said display monitor to display said simulated images; and

quantifying a diagnostic value of each image simulated based at least in part on an image quality specification to produce simulation-based image quality data.

insert claim 2 similar here

15. The computer system as recited in claim 14, wherein said image quality specification comprises at least a portion selected via said operator interface.

16. The computer system as recited in claim 14, wherein said operator interface comprises a graphical user interface for selecting said statistical design of experiment.

17. The computer system as recited in claim 14, wherein said operator interface comprises a graphical user interface for setting said at least one imager parameter.

18. The computer system as recited in claim 14, wherein said operator interface comprises a graphical user interface for specifying at least said portion of said probe geometry specification.

19. The computer system as recited in claim 14, wherein said probe geometry specification comprises a specification of layers in said probe,

and said simulating step comprises the step of computing an impulse response based at least in part on said specification of layers in said probe.

20. The computer system as recited in claim 19, wherein said set of imager parameters comprises a definition of aperture geometry, and said simulating step further comprises computing acoustic diffraction based at least in part on said impulse response, said definition of aperture geometry and said phantom.

21. The computer system as recited in claim 14, further comprising a database containing respective sets of imager parameters for pre-existing probes, wherein at least some of said imager parameters are retrieved from said database.

22. The computer system as recited in claim 19, wherein said step of computing an impulse response employs a one-dimensional acoustic stack design.

23. The computer system as recited in claim 19, further comprising programming for generating transfer functions based at least in part on said simulation-based image quality data.

24. The computer system as recited in claim 23, wherein said image quality specification is a function of at least one image quality parameter, and at least one of said transfer functions relates said image quality parameter to said subset of imager parameters.

25. The computer system as recited in claim 24, further comprising programming for deriving a statistical distribution of said image quality parameter as a function of at least one imager parameter of said subset using at least one of said transfer functions.

26. The computer system as recited in claim 23, wherein said image quality specification specifies a value representing an overall image quality, and at least one of said transfer functions relates said overall image quality value to said subset of imager parameters.

27. The computer system as recited in claim 14 wherein said image quality specification is a function of at least the following: an image quality parameter and a range-dependent weighting coefficient corresponding to said image quality parameter.

28. The computer system as recited in claim 23, further comprising programming for optimizing imager parameters of said probe and imager combination based at least in part on said transfer functions.

29. The computer system as recited in claim 23, further comprising programming for optimizing said specification of layers in said probe based at least in part on said transfer functions.

30. The computer system as recited in claim 23, further comprising programming for controlling said display monitor to display a graph representing image quality as a function of cost based at least in part on said transfer functions. .

31. A computer system for jointly optimizing a performance of a probe and imager combination in an ultrasound imaging system, comprising:

a processor;

a display monitor;

an operator interface;

means for simulating images of a phantom which would be produced by said probe and imager combination in accordance with a statistical design of experiment selected via said operator interface, a probe geometry specification comprising at least a portion specified via said operator interface, and a set of imager parameters comprising at least one imager parameter set via said operator interface, said statistical design of experiment allowing a subset of said imager parameters to vary;

means for controlling said display monitor to display said simulated images; and

means for quantifying a diagnostic value of each image simulated based at least in part on an image quality specification to produce simulation-based image quality data.

32. A computer system comprising first and second computers connected via a network, wherein said first computer is programmed with transducer design advisor software for generating a series of graphical user interface windows, creating files which define a design of experiment analysis based at least in part on inputs to said windows, and uploading said files to said second computer, and said second computer is programmed with simulation software for simulating images of a phantom in accordance with a design of experiment defined by said uploaded files.

33. The computer system as recited in claim 32, wherein said second computer is further programmed with file server software which handles transactions between said transducer design advisor software and said simulation software.

34. The computer system as recited in claim 32, wherein first computer is further programmed with spreadsheet software having a design of experiment toolset for creating a design of experiment matrix, and said second computer is further programmed with analysis server software which provides communications links between said simulation software and said spreadsheet software.

35. The computer system as recited in claim 32, wherein said simulation software comprises acoustic stack simulation software, ultrasound beam simulation software, and design of experiment software for performing simulations in a design of experiment mode.

36. The computer system as recited in claim 32, wherein said second computer is further programmed with scoring software which calculates an image quality value using weighting coefficients received from said first computer.

37. The computer system as recited in claim 34, wherein said second computer is further programmed with scoring software which calculates an image quality value using weighting coefficients received from said first computer, and said design of experiment

toolset comprises a regression tool for generating transfer functions based at least in part on said scoring.

38. (Deleted).

39. (Deleted).